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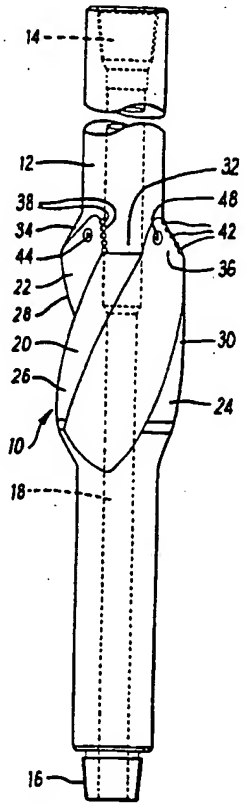
(54) Title: WELL DRILLING TOOLS

(57) Abstract

A back-reaming stabiliser (10) for incorporation in a bottom-hole assembly (BHA) on the downhole end of a drillstring. The stabiliser consists of a conventional fixed-blade stabiliser having added to it rows of PDCs (38, 40, 42) or other suitable hard inserts along the upper edges of the blades (20, 22, 24) to act as back-reaming cutters, nozzles (44, 46, 48) for directing mud at these cutters during back-reaming, and a valve (50) normally closing these nozzles. The valve is opened by remote actuation immediately prior to the start of back-reaming. The valve is preferably a sleeve (50) normally held over the nozzles by shear pins (58) which are ruptured by a flow-flocking drop member (60). The drop member preferably has a through bore (76, 78) initially blocked by a burstable diaphragm (80) such that after the sleeve (50) is opened by the drop member, mud pressure can be increased to burst the diaphragm (80) and re-open a passage for mud to the downhole end of the bottom-hole assembly. This divides mud flow between an upflow past the outside of the stabiliser, and mud jets through the nozzles to the back-reaming cutters. The invention avoids the wastage of mud that would occur if the back-reaming cutter nozzles were permanently open.



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"Well Drilling Tools"

This invention relates to well-drilling tools, and relates more particularly but not exclusively to a well-drilling tool in the form of a back-reaming stabiliser incorporating back-reaming cutter means and valve means controllably operable to divert well-drilling fluid to said cutter means.

The back-reaming stabiliser is particularly but not exclusively applicable to the drilling of wells where the drilled formation may swell or slough into the wellbore and thereby restrict egress of the drillstring. In this context, it is known that the drilling of wells, particularly oil wells, through geological formations which are under extreme local pressures has inherent problems due to the wellbore becoming restricted by these rocks swelling or sloughing into it. In certain instances the formation will exhibit a plastic flow and may restrict the wellbore diameter over many metres.

To counteract this problem it has been common practice to use the uppermost drillstring stabiliser (furthest

from bit) in the BHA (bottom hole assembly) as a back-reaming stabiliser if a restriction is encountered during withdrawal of the drillstring from the wellbore. In such an instance the drillstring is withdrawn slowly from the wellbore whilst rotating at normal drilling speeds, such that the stabiliser blades cut or ream a passage back through the restricted zone. However, this has the disadvantage that the use of a drillstring stabilising element not specifically designed for a cutting operation is:-

(a) a slow and laborious, and therefore expensive operation; and

(b) the stabiliser is usually seriously damaged as a consequence.

A stabiliser which is specifically designed to have an additional back-reaming function by the provision of suitably located cutters will usually require that the cutters be supplied with mud or other appropriate well-drilling fluid for the purposes of cooling, lubrication, and debris removal. The mud will be supplied to the cutters by way of nozzles in the stabiliser. The same mud or other well-drilling fluid will be similarly supplied to the drillbit normally present at the downhole (bottom) end of the BHA. However, the drillbit and the back-reaming cutters will be required to work at mutually different times, according to whether the intended direction of progress of the drillstring is downhole or uphole. Accordingly, the simultaneous supply of mud to the drillbit and to the back-reaming cutters represents an inefficient use of the mud supply, the inefficiency manifesting itself, for example, as an unnecessarily high power consumption

by the mud pump. Nevertheless, the back-reaming cutters must be reliably supplied with mud or other appropriate well-drilling fluid during back-reaming operation.

It is therefore an object of the invention to provide an improved back-reaming stabiliser.

According to the present invention there is provided a back-reaming stabiliser comprising a tubular body from which a plurality of stabiliser blades extend, said tubular body having a through passage for hydraulic fluid to flow internally through said tubular body between opposite ends of said stabiliser in use thereof, said stabiliser blades extending radially outwards of said tubular body, said stabiliser blades extending longitudinally at least partially along said tubular body, said stabiliser blades extending circumferentially at least partially around said tubular body, radially outer edges of said stabiliser blades being formed as wellbore-bearing surfaces to provide a radially supportive function in use of said stabiliser, longitudinally common end edges of said stabiliser blades being formed as back-reaming cutter means, and fluid vent means coupling said through passage to the exterior of said stabiliser for the flow therethrough of hydraulic fluid from said through passage to said cutter means, said back-reaming stabiliser being characterised by further comprising valve means normally closing said fluid vent means to the flow of hydraulic fluid therethrough, said valve means being selectively operable during downhole use of said stabiliser to open said fluid vent means to the flow of hydraulic fluid therethrough.

Said valve means may comprise a sleeve means movable in said through passage between a first position of said sleeve means in which said sleeve means closes said fluid vent to the passage of hydraulic fluid therethrough, and a second position of said sleeve means in which said sleeve means opens said fluid vent means to the passage of hydraulic fluid therethrough, said sleeve means being movable from said first position thereof to said second position thereof by the application of a substantial pressure differential between longitudinally opposite ends thereof. Said sleeve means is preferably normally retained in said first position thereof by shear means rupturable by said application of said substantial pressure differential between longitudinally opposite ends of said sleeve means thereupon to release said sleeve means from said first position thereof for movement to said second position thereof. Movement of said sleeve means from said first position thereof to said second position thereof may be by way of sliding movement longitudinally along said through passage. Said sleeve means may be formed with an internal passage extending longitudinally therethrough and locally defining said through passage of said stabiliser, said substantial pressure differential being created by causing an at least temporary blockage of flow of hydraulic fluid through said internal passage extending longitudinally through said sleeve means. Such hydraulic flow blockage may be caused by manoeuvring a flow-blockage-inducing means into said internal passage through said sleeve means. Said flow-blockage-inducing means may comprise a drop means introduced to said stabiliser by being dropped into the bore of the drillstring of which the stabiliser forms part. Said drop means preferably comprises a generally tubular

member having a longitudinal through bore initially blocked to the passage of hydraulic fluid therethrough by a rupturable diaphragm extending thereacross, said tubular member being formed to lodge in said sleeve means, preferably by forming said tubular member with an external shoulder dimensioned to engage positively with said sleeve means which may be formed with an internal shoulder for that purpose.

Said longitudinally common end edges of said stabiliser may be formed as said back-reaming cutter means by embedding a plurality of hard inserts in leading portions of said edges, preferably so as to lie substantially in a common notional surface of revolution, which surface may be conical. Each said hard insert may be a PDC (polycrystalline diamond compact), or a chip of tungsten carbide. Said fluid vent means may comprise a respective fluid nozzle adjacent each said cutter-formed end edge of said stabiliser blades.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawings wherein:-

Fig 1 is an elevation of an embodiment of back-reaming stabiliser in accordance with the invention;

Fig 2 is a plan view of the stabiliser of Fig 1;

Fig 3 is a longitudinal section of the stabiliser of Fig 1, taken on the line III-III in Fig 2;

Fig 4 is a transverse section of the stabiliser of

Fig 1, taken on the line IV-IV in Fig 3; and

Fig 5 is a longitudinal section, to a much-enlarged scale, of a drop member for use with the stabiliser of Fig 1.

Referring first to Figs 1-4 (which are different views of the same article, to a common scale), a back-reaming stabiliser 10 in accordance with the present invention is basically formed as a conventional fixed-blade stabiliser, though with certain modifications and additions (detailed subsequently) to meet the object of the invention.

The stabiliser 10 comprises an elongate tubular body 12 having a standard API (American Petroleum Institute) box connector 14 at it upper end, and a standard API pin connector 16 at its lower end. The connectors 14 and 16 enable the stabiliser 10 to be coupled into a BHA (bottom hole assembly; not shown), the BHA being connected to the downhole end of a drillstring (not shown).

The tubular body 12 has a through passage 18 for carrying a flow of mud (well-drilling fluid) or other hydraulic fluid between the connectors 14 and 16 in use of the stabiliser 10.

In a known manner, the body 12 is integrally formed with three stabiliser blades 20, 22 and 24 each extending radially outwards of the body 12 along a central part of its length. The blades 20-24 are equi-angularly located around the body 12 (see Figs 2 and 4), and are spirally shaped (see Fig 1) such that, as a whole, the blades 20-24 extend circumferentially

around the body 12 to define the outer periphery of the stabiliser 10 (see Fig 2). The respective radially outer edges 26, 28 and 30 of the stabiliser blades 20, 22 and 24 are formed as wellbore-bearing surfaces such that the stabiliser 10 provides the conventional radially supportive function in operation as part of a BHA.

The respective upper ends 32, 34 and 36 of the stabiliser blades 20, 22 and 24 are formed as back-reaming cutters by being each inset with a respective row of PDCs 38, 40 and 42 which collectively sit on a notional cone coaxial with the stabiliser 10 and converging upwardly. The body 12 is fitted with three radially directed nozzles 44, 46 and 38 between each of the cutter sets 38-42 (see Figs 2, 3 and 4). The nozzles 44-48 are each fed from the central through passage 18 during back-reaming, but during normal downwardly directed drilling, the nozzles 44-48 are closed off by a sleeve 50 (Figs 3 and 4) which is a sliding fit in the bore of the through passage 18. The sleeve 50 is held in a position in which it normally blocks fluid flow to the nozzles 44-48 by being secured to the lower end of a tubular mounting 52 having an external shoulder 54 which sits on a matching shoulder 56 in the bore of the through passage 18. The sleeve 50 is secured to the mounting 52 by means of shear pins 58 (Fig 3; only one pin being visible).

When the stabiliser 10 is required to operate as a back-reamer, it is necessary to initiate flow of well-drilling fluid outwards through the nozzles 44, 46 and 48 for the reasons previously discussed. Consequently, it is necessary to slide the sleeve 50 down the bore of the through passage to a position in

which the sleeve 50 no longer blocks fluid outflow through the nozzle 44-48. Since the stabiliser 10 will at that time be part of a BHA deep down a well, remote operation of the sleeve 50 is clearly necessary (ie direct manual movement of the sleeve 50 in such circumstances is utterly impossible). A drop member 60 for achieving such remote movement of the sleeve 50 will now be detailed with reference to Fig 5 (wherein the drop member 60 is depicted to a much larger scale than the stabiliser 10 is shown in Figs 1-4).

Referring to Fig 5, the drop member 60 is generally tubular in shape and has an external diameter sufficiently small as to allow the member 60 to drop down the bore of the drillstring, and to enter the bore of the sleeve mounting 52 (Fig 3). The upper end of the drop member 60 is formed with a small external shoulder 62 dimensioned to seat on an internal shoulder 64 at the lower end of the sleeve 50 (Fig 3). The external diameter of the drop member 60 below the shoulder 62 is marginally less than the internal diameter of the sleeve shoulder 64 so as to allow the drop member 60 to pass down through the sleeve 50 until the shoulder 62 seats on the sleeve shoulder 64, whereupon all further downward movement of the drop member 60 is halted.

The drop member 60 is formed of an upper component 66 and a lower component 68 which are normally mutually secured by means of a screw thread 70, a tight threaded connection of the components 66 and 68 conveniently being achieved by the application of spanners (not shown) to external flats 72 and 74. The components 66 and 68 have respective longitudinal through bores 76 and 78 which are initially sealed off one from the

other by means of a burstable diaphragm 80 clamped between the components 66 and 68 to extend fully across the bores 76 and 78.

Operation of the invention will now be described. As described above with reference to Figs 1-4, the stabiliser 10 provides the conventional radially supportive function of the conventional fixed-blade stabiliser which it resembles, and which need not be further detailed. When required to function as a back-reamer, normal rotation of the stabiliser 10 is continued (clockwise as viewed from above, ie clockwise as viewed in Figs 2 and 4), but a suitable upforce is applied to the drillstring and through it, the upforce is applied to the BHA of which the stabiliser 10 is a part. This causes the cutter sets 42, 44 and 46 to bite into the wellbore intrusion. As already detailed, the nozzles 44, 46 and 48 have to be opened prior to commencement of back-reaming. Between the termination of down-drilling and the commencement of back-reaming, the drop member 60 is released into the bore of the drillstring to drop down or be forced by pumped mud to the stabiliser 10 wherein it passes down the through bores of the sleeve mounting 52 and of the sleeve 50, until the external drop member shoulder 62 lodges on the internal sleeve shoulder 64 to halt the downward movement of the drop member 60. In this position, the drop member 60, together with the diaphragm 80, restrict or block the flow of mud down the drillstring. When the mud-induced downforce on the drop member 60 becomes sufficiently high (with increased mud pumping, if necessary), the shear pins 58 will rupture and thereby allow the sleeve 50 to be moved downwards from its initial nozzle-blocking position as shown in Fig 3, to a lower position in which the nozzles 44, 46, and 48

are opened for outflow of mud therethrough as previously detailed. Next, the pressure of the mud on the diaphragm 80 is increased (notwithstanding the now-commenced mud outflow through the nozzles 44-46), eg by increasing the working speed of the mud pumps (not shown), to a level at which the diaphragm 80 bursts, thereby re-establishing mud flow down through the stabiliser 10 to the drillbit.

The collective rupturing force of the shear pins 58 at any given mud pressure will be selected to be less than the equivalent rupturing force of the diaphragm 80 at the same mud pressure, ie it will be arranged that the shear pins 58 will always rupture before the diaphragm 80 ruptures to ensure the intended sequence of operations.

Mud flow down the drillstring is now split between the stabiliser nozzles 44-48 and the drillbit nozzles (not shown) in proportion to their relative flow areas, with the greater portion of mudflow preferably going through the drillbit to establish a substantial upflow of mud past the exterior of the stabiliser 10 for removal of debris arising from back-reaming operation of the cutters 38-42. The lesser portion of mudflow goes through the nozzles 44-48 to provide the cooling, lubrication, and cleaning functions previously detailed.

As the back-reaming operation takes place the drillstring will be rotated at normal drilling speeds as it is slowly withdrawn from the wellbore. The cutters mounted on each stabiliser blade will cut and remove the formation and hence permit the egress of the BHA past the restriction.

The above example is cited as a simple, effective but non-repeating means of back-reaming through a wellbore restriction. By adaption of the mechanism used to divert the mud flow through the stabiliser nozzles, it would be possible to have a back-reaming stabiliser capable of back-reaming through a number of restrictions in the wellbore. This repeatability could be engendered by the use of sleeves or special valves in the stabiliser body; valves which may be activated by either hydraulic or mechanical means which would return to a detente position when the means of activation was removed.

Whichever flow diverting valve means is used it is preferred that the through bore of the stabiliser is such that fishing and survey equipment may pass through it without impinging on the valve operating mechanism or snagging on any shoulders or ledges.

While certain modifications and variations have been described above, the invention is not restricted thereto, and other modifications and variations can be adopted without departing from the scope of the invention as defined in the appended claims.

Claims

1. A back-reaming stabiliser comprising a tubular body from which a plurality of stabiliser blades extend, said tubular body having a through passage for hydraulic fluid to flow internally through said tubular body between opposite ends of said stabiliser in use thereof, said stabiliser blades extending radially outwards of said tubular body, said stabiliser blades extending longitudinally at least partially along said tubular body, said stabiliser blades extending circumferentially at least partially around said tubular body, radially outer edges of said stabiliser blades being formed as wellbore-bearing surfaces to provide a radially supportive function in use of said stabiliser, longitudinally common end edges of said stabiliser blades being formed as back-reaming cutter means, and fluid vent means coupling said through passage to the exterior of said stabiliser for the flow therethrough of hydraulic fluid from said through passage to said cutter means, said back-reaming stabiliser being characterised by further comprising valve means normally closing said fluid vent means to the flow of hydraulic fluid therethrough, said valve means being selectively operable during downhole use of said stabiliser to open said fluid vent means to the flow of hydraulic fluid therethrough.

2. A back-reaming stabiliser as claimed in Claim 1, wherein said valve means comprises a sleeve means movable in said through passage between a first position of said sleeve means in which said sleeve means closes said fluid vent to the passage of

hydraulic fluid therethrough, and a second position of said sleeve means in which said sleeve means opens said fluid vent means to the passage of hydraulic fluid therethrough, said sleeve means being movable from said first position thereof to said second position thereof by the application of a substantial pressure differential between longitudinally opposite ends thereof.

3. A back-reaming stabiliser as claimed in Claim 2, wherein said sleeve means is normally retained in said first position thereof by shear means rupturable by said application of said substantial pressure differential between longitudinally opposite ends of said sleeve means thereupon to release said sleeve means from said first position thereof for movement to said second position thereof.

4. A back-reaming stabiliser as claimed in Claim 2 or Claim 3, wherein movement of said sleeve means from said first position thereof to said second position thereof is by way of sliding movement longitudinally along said through passage.

5. A back-reaming stabiliser as claimed in Claim 2 or Claim 3 or Claim 4, wherein said sleeve means is formed with an internal passage extending longitudinally therethrough and locally defining said through passage of said stabiliser, said substantial pressure differential being created by causing an at least temporary blockage of flow of hydraulic fluid through said internal passage extending longitudinally through said sleeve means.

6. A back-reaming stabiliser as claimed in Claim 5, wherein said hydraulic flow blockage is caused by manoeuvring a flow-blockage-inducing means into said internal passage through said sleeve means and said flow-blockage-inducing means comprises a drop means introduced to said stabiliser by being dropped into the bore of the drillstring of which the stabiliser forms part.

7. A back-reaming stabiliser as claimed in Claim 6 wherein said drop means comprises a generally tubular member having a longitudinal through bore initially blocked to the passage of hydraulic fluid therethrough by a rupturable diaphragm extending thereacross, said tubular member being formed to lodge in said sleeve means.

8. A back-reaming stabiliser as claimed in Claim 7 wherein said tubular member is formed with an external shoulder dimensioned to engage positively with said sleeve means.

9. A back-reaming stabiliser as claimed in any preceding claim wherein said longitudinally common end edges of said stabiliser are formed as said back-reaming cutter means by embedding a plurality of hard inserts in leading portions of said edges.

10. A back-reaming stabiliser as claimed in Claim 9 wherein said inserts are located so as to lie substantially in a common notional surface of revolution.

11. A back-reaming stabiliser as claimed in Claim 10 wherein said notional surface of revolution is

conical, and convergent in the longitudinal direction of back-reaming operation.

12. A back-reaming stabiliser as claimed in any preceding claim wherein said fluid vent means comprises a respective fluid nozzle adjacent each said cutter-formed end edge of said stabiliser blades.

13. A back-reaming stabiliser as claimed in any preceding claim wherein said valve means is adapted for controllable cyclic operation repeatedly to open and close said fluid vent means to the flow of hydraulic fluid therethrough at selected times whereby said stabiliser may undertake plural episodes of back-reaming operation between which episodes said valve means re-closes said fluid vent means to the flow of hydraulic fluid therethrough.

14. A back-reaming stabiliser as claimed in claim 13 wherein said valve means is adapted to open upon the application thereto of a valve-opening force, and to close automatically upon cessation of said valve-opening force.

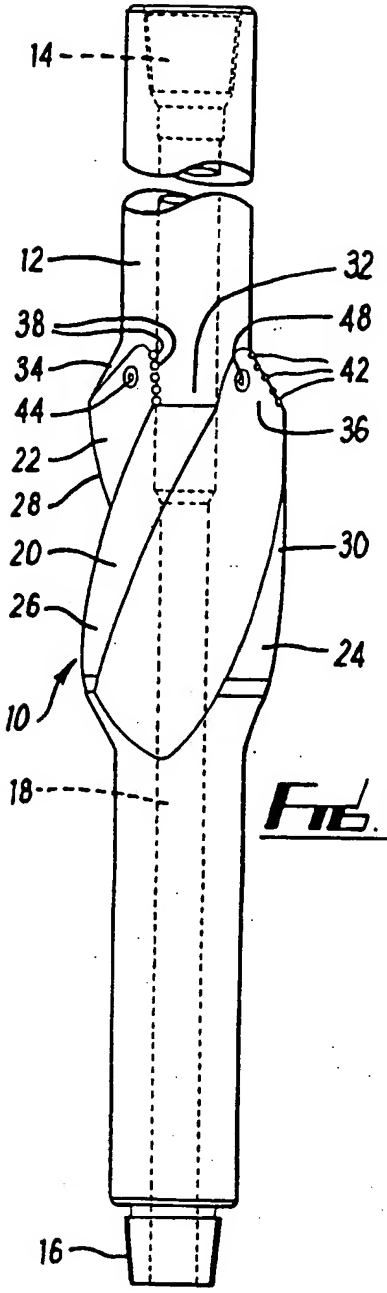


FIG. 1

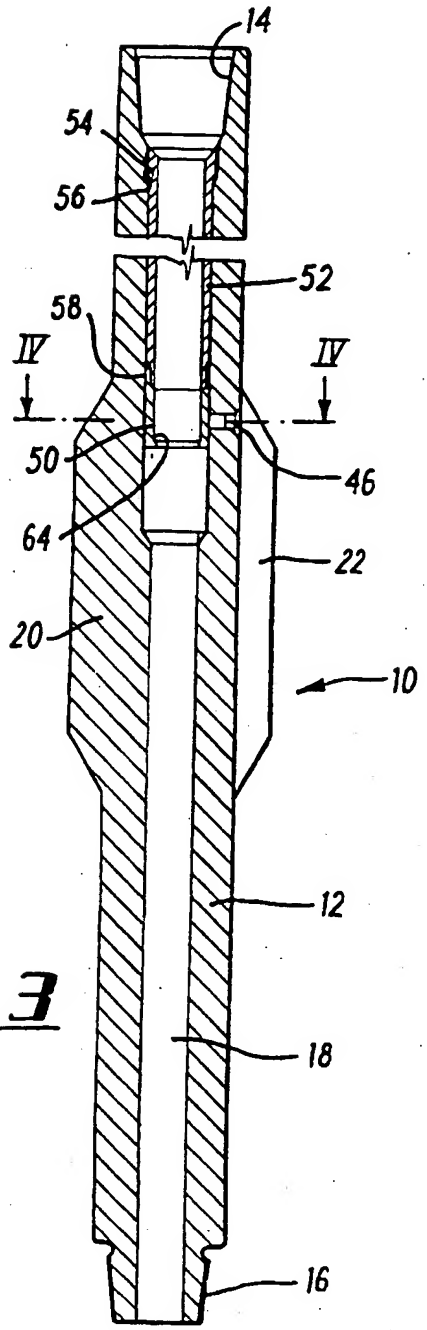


FIG. 3

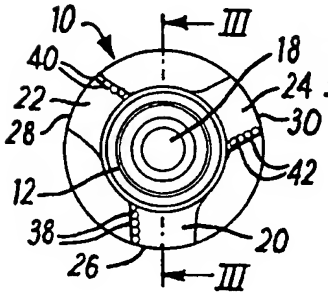


FIG. 2

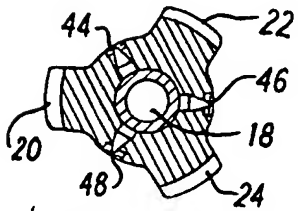


FIG. 4

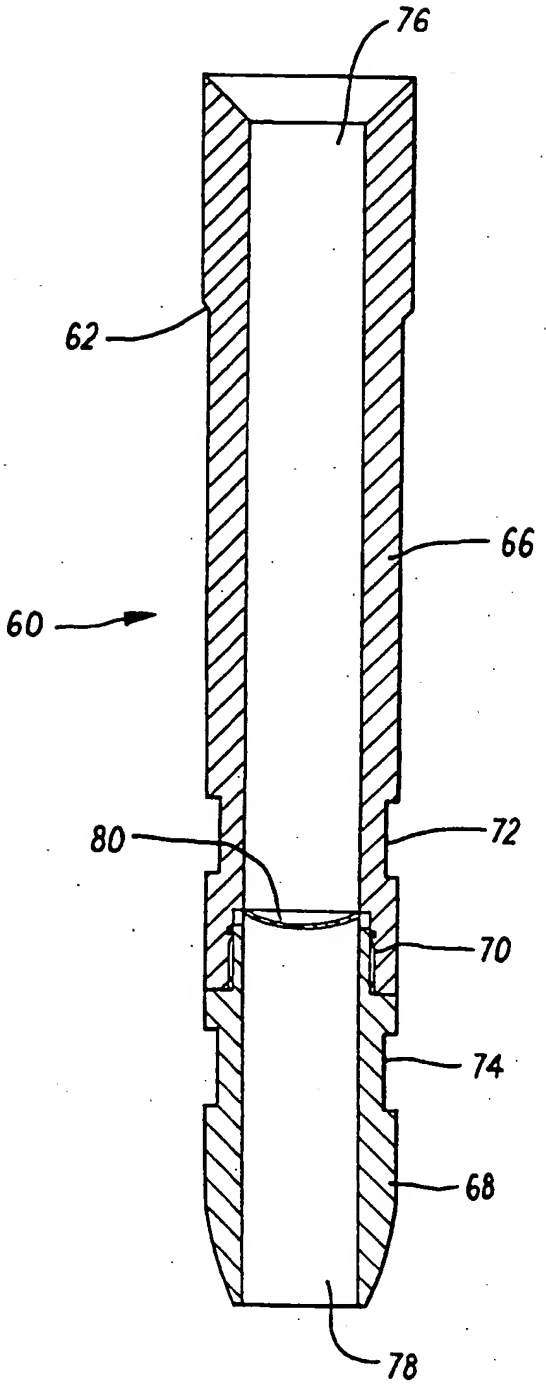


FIG. 5

# INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 93/01203

## I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 E21B10/26; E21B10/60; E21B34/10; E21B34/14
E21B21/10; E21B17/10

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Minimum Documentation Searched[7]

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| Int.Cl. 5 | E21B |

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

## III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

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## IV. CERTIFICATION

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| 19 OCTOBER 1993 | 11. 11. 93 |
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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

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# ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

GB 9301203
SA 75783

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 19/10/93
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